AD-751 955

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Wright-Patterson Air Force Base, Ohio

27 October 1972

AD751955

FTD-HT-23-1410-72

FOREIGN TECHNOLOGY DIVISION

AIR FORCE SYSTEMS COMMAND

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EDITED TRANSLATION

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Source: AN SSSR. Sibirskoye Otdeleniye. Avtometriya, No. 1, 1971, pp. 77-81.

Requester: FTD/PDTA

Translated by: TSgt Victor Mesenzeff

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Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

* ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Foreign Technology Division Air Force Systems Command U. S. Air Force	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE

USE OF COHERENT OPTICAL COMPUTERS FOR SOLVING PROBLEMS OF INFORMATION RETRIEVAL

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Translation

5. AUTHOR(S) (First name, middle initial, last name)

Voskoboynik, G.A.; Gibin, I.S.;

6. REPORT DATE 1971	7a. TOTAL NO. OF PAGES 8/13	7b. NO. OF REFS
8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. d. T71-05-09 T71-05-13	9a. ORIGINATOR'S REPORT NUMBER(S) FTD-HT-23-1410-72 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Foreign Technology Division Wright-Patterson AFB, Ohio

13. ABSTRACT

Microfiche of abstract contains graphic information. The paper describes a Ata retrieval system which utilizes coherent optical computer elements for finding chemical substances from their spectral and numerical characteristics. A block diagram of the system is shown in the figure. The data retrieval system is comprised of a light source 1, collimator 2, a transparency 3 which contains the request in the form of a composite image. Objective lens 4 which produces the spectrum of the input image in the plane of hologram plate 5 (the fixed memory). Another objective lens 6 and a photoelectric readout mofule 7. The device operates on continuous or pulse lasers at 0.6328 micron, uses a transparency measuring 16X60 mm, has focal length of the objective lens of 0-440 mm, a hologram memory plate measuring 90X120 mm with a resolution of at least 800 lines per mm, holograms are 3 mm in diameter, the plate accommodates a maximum of 1,000 holograms, and the maximum capacity of a single hologram is 30,000 bits. A photographic plate can be changed in 4-5 s and information retrieval time in a memory of 1,000 holograms is 50 ms. Search with respect to two independent characteristics is possible, and provision is made for visual comparison of the request image with any of the recorded holograms. Use of the proposed device in other branches of science is feasible.

DD FORM 1 NOV 65 1473

UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Optic Computer						
Information Storage and Retrieval						
Chemical Analysis						
Hologram						
Pulse Laser						
Photo Cell						

USE OF COHERENT OPTICAL COMPUTERS FOR SOLVING PROBLEMS OF INFORMATION RETRIEVAL

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Automated systems designed for accumulation, storage, and data retrieval are called information retrieval systems (IRS). The retrieval of information in the IRS is accomplished via the request composed of coded graphic, literal numeric, and other characteristics. The content of the request is compared (in a certain sense) with the IRS storage content, after which the operator is given either the information in which he is interested or its address.

From the content of the problem of data retrieval it follows that the IRS should have a large storage volume and ensure a fast data retrieval using one or several characteristics. Therefore, its solution is accomplished most frequently by means of an electronic digital computer. However, the IRS operation based on digital computer is not always justifiable economically and requires a considerable amount of time for numerical coding, input, and data processing in those prevalent cases when the inquiry includes the image characteristics. These circumstances force us to look for other variants for the technical realization of the IRS.

In this respect, our attention is drawn to the optical variants of IRS and especially those which are based on the use of coherent optical computers (KOVU). As compared to the non-coherent variants of optical devices, they have considerable advantages, such as the capability for image processing beforehand; increased interference rejection ensured by the holographic means of data storage; capability for computation of the various functionals of functions describing the request and information stored in the memory; simplicity of a simultaneous separate data retrieval using several characteristics, etc.

A block diagram of the IRS system with the use of the KOVU elements is shown in Fig. 1. Indicated on it are: coherent light source 1; collimator 2; transparency 3 which contains the request in the form of a composite image; objective 4 by means of which the spectrum of the input image is obtained in the hologram plane; plates 5 with holograms (fixed memory); objective 6 and a photoelectric readout unit 7. Continuous or pulsed lasers can be used as the coherent light source. The collimator expands the laser beam, forming a plane wave front.

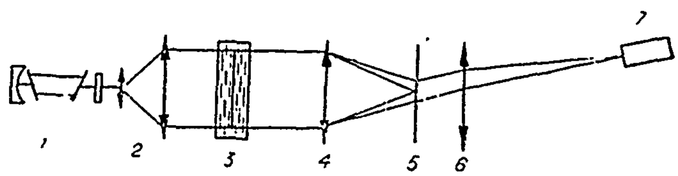

Fig. 1.

Content of the request is introduced into the IRS by means of space modulation of the coherent light wave. In order to increase the accuracy of comparison and decrease the requirements as applied to the readout unit, the image in the input plane can be stabilized using orientation and displacement in the fixed system of coordinates.

The image characteristics can be given in half-tone or two-gradation form. However, if the characteristic is a function of one variable, then it is advisable to present it in the form of an outline or a silhouette. In this case the effect of nonlinear characteristic of the material, from which the transparency is made, can be decreased considerably. In setting numerical characteristics it is advisable that direct or indirect masks be used; moreover, in order to increase the accuracy of comparison it is better to reduce the number on the transparency in the code which is opposite to that in which the recording of numbers into the memory was accomplished.

The principle operation in data retrieval is the operation for calculating the function of mutual correlation of images. Let $F(x, y)$ and $\Phi_m(x, y)$, $m = 1, 2, \ldots,$ and M - amplitude gating functions according to the image on the transparency and images in the memory. Then the preparation of a fixed memory and IRS operation (Fig. 1) can be accomplished by different methods.

1. If the M images are written simultaneously and successively onto the hologram, then when the request is presented to the output of readout unit 7 we will obtain a light distribution equivalent to the M functions of mutual correlation. It is obvious that with large M the level of the output signal will be very low. In addition to the considerable demands placed on the photoelectric converters, in this case, difficulties arise in processing the light distribution in order to extract information on proximity of $F(x, y)$ and $\Phi_m(x, y)$. The retrieval using several characteristics is also made more difficult.

2. Each of the M images is recorded in the memory on an individual hologram. Then computation of the mutual correlation function is accomplished in sequence either by shifting plate 5

or via the two-coordinate deflection of a beam carrying information concerning the request. It is clear that in this case it is possible to obtain an output signal with a good signal/noise ratio for each of the M images. Correlation functions are reproduced in the same location of the output plane, which makes it possible to use one photoreceiver for the readout of the correlation coefficients. However, if the mask with a predetermined law of gating is placed before the photoreceiver, then it is possible to calculate the degrees of closeness of the images different from that of the correlational.

The readout unit of the IRS is designed to accomplish the following: convert a light signal into an electric signal, determine the degrees of closeness, receive a solution, and give information (or its address) in the form suitable for use upon request. In this case photoelectric conversion can be accomplished by means of the photoelectric multipliers, dissectors, vidicons, and others. Address of the hologram restored by an additional beam can be read by means of the photodiode or phototransistor rule. Solution concerning the correspondence of the content of request and content of memory is carried out, in a number of cases, by comparing the found degree of closeness of the images with a threshold value calculated beforehand.

Two IRS versions based on the KOVU elements have been developed at the Institute of Automation and Electrometry, SO AS USSR. In the first of them, consecutive computation of the mutual correlation functions has been achieved by means of the two-coordinate displacement of the plate with the holograms. However, more up to date is the second version of IRS whose diagram is shown in Fig. 2.

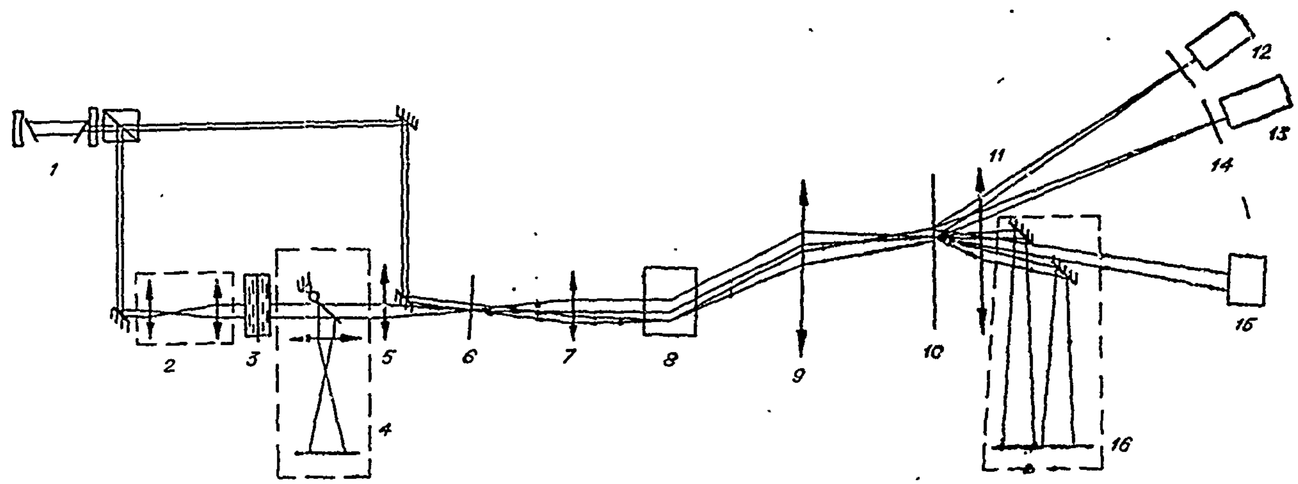

Fig. 2.

Helium neon laser LG-36A was used as light source 1. Collimator 2 permits us to obtain a light beam 80 mm in diameter. The request is introduced by means of the transparency which 's submerged into immersion bath 3. Using projector 4 with an eight-power magnification, the transparency can be placed on the input plane with an accuracy up to ±0.05 mm. In the specified focal plane of objective 5 there is filter 6 which permits (when necessary) filtration of noises of the input image. Objective 7 projects the transparency image on one of the deflector mirrors. The deflector is a rotating drum on the surface of which are 20 mirrors positioned at various angles to the generatrix. As the drum rotates, there is a deflection of the signal beam both with respect to vertical as well as the horizontal. All holograms located on photoplate 10 are scanned in one turn of the drum. Since the deflecting mirrors of the drum are in focus of objective 9 during the operational cycle, all light fluxes hitting photoplate 10, independently of the hologram position, will be parallel with an accuracy up to difractional divergence and, consequently, will form the same angle with the reference beam in producing the hologram memory. An important hologram characteristic is their informational capacity. For this system this characteristic expressed in the number of bits of information can be determined by formula

$$N = \frac{S d^2}{4 m^2 f^2 \lambda^2},$$

where S - area (useful) on the transparency; d - hologram diameter; m - number of recorded spectrum orders of the smallest element of the input image; f - focal length of objective 9; λ - wavelength of luminous radiation. It is obvious that when determining the informational capacity of the hologram memory it is necessary to multiply number N by the number of holograms located on a photoplate of certain dimension.

The signal beam which passed through a particular hologram is transformed by objective 11 and strikes photoreceiver 13 located in front of which is mask 14 by means of which the required degree of closeness is calculated. Process for reading the degrees of closeness is synchronized by a signal from the output of photoreceiver 12. In the read moment this signal is maximal and proportional to the correlation coefficient of identical images-signs one of which is recorded on each of the memory holograms, while the other is contained in the input image.

In the examined IRS version there is also an auxiliary channel. It is designed for reproduction of information contained in a particular hologram. Part of this information is visualized on screen 16, while the hologram address is read by multielement photoreceiver 15. The signal from the output of photoreceiver 13 is fed to the threshold device (not shown in Fig. 2). If the level of this signal exceeds the established threshold, then the hologram address read by photoreceiver 15 is transferred to the lighted panel indicator.

We will give the principle parameters for the described IRS version: radiation wavelength - 0.6328 μm; transparency dimension - 16 × 60 mm; objective focal length - 9-440 mm; dimensions of the hologram memory photoplate - 90 × 120 mm; plate resolution not less than 800 lines/mm; hologram diameter - 3 mm; maximum number of holograms on photoplate - 10^3; maximum capacity of one hologram - $30 \cdot 10^3$ bits; time it takes to change the photoplate - 4-5 s; information retrieval time in a memory of 10^3 holograms - 50 ms; search with respect to two independent characteristics is possible, and provision is made for visual comparison of the request image and the image recorded on any of the holograms.

The system is developed taking into account the peculiarities of the problem of retrieval of chemical substances using their spectral and numerical characteristics. In this case the image corresponding to the request looks the way it appears in Fig. 3 (the figure shows a negative image relative to the actual). There is a transparent section on the left side of the image. Its function is to pass the light flux with the formation of a sign. Shown in the center is an image of a curve characterizing the coefficient of light absorption by the substance as a function of wavelength; on the right side is a code image of a three-digit numerical characteristic (melting point, specific gravity, etc.). The number of units in each digit is porportional to the angle of turn of the corresponding half-ring.

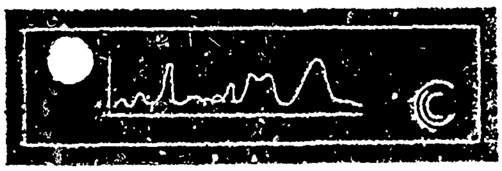

Fig. 3.

Thus, proceeding from the speed, informational capacity, and other characteristics of the described IRS version it is possible to consider the application of KOVU for solving the problem of data retrieval in chemistry (retrieval of substances using their spectral and numerical characteristics), biology (identification of cells using the nature of their activity), geology (to determine the presence of useful minerals depending on the type of microorganisms found in samples), etc.

Submitted
3 September 1970